

Climate Prisms: The Arctic

Connecting Climate Research and Climate Modeling via the Language of Art

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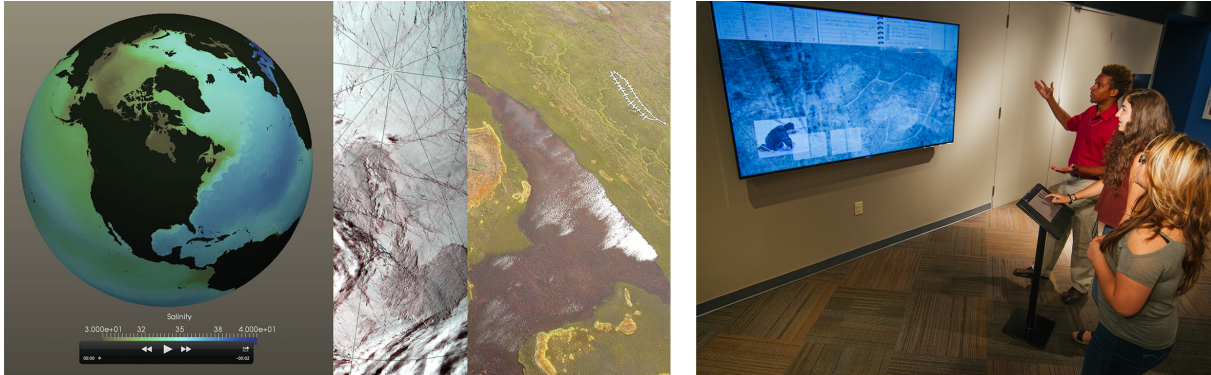


Figure 1: Left to right: an example from *Climate Prisms* showing a visualization of ocean salinity; an Arctic map; an aerial photograph of a research site; and participants interacting with *Climate Prisms: The Arctic*.

ABSTRACT

Climate science is conveyed via visualization of a climate model – an abstraction that removes the science from the research field activity that forms the basis for constructing the model. *Climate Prisms: The Arctic* is about bridging the distance between the physical world and the scientific visualization through multiple approachable modalities: visual art, literature, scientific text, information graphics, field imagery and others. By allowing participants to view science through different lenses, each person plots their own path, moving through the content at the pace and level that best enables them to engage with the material. The project itself is a large display screen driven by a touch interface designed for individual or small group viewing. Content paths are determined by an underlying system of tags, levels, content categories and related research areas. A screen shows a set of images. Each image can be accessed to provide image-specific information or can be a launching pad for a new set of related content and images that allows the user to continue on their exploration journey. Each person creates a unique path through over 2000 pieces of content. Embedded assessment will log basic demographics and each individual foray through the content. These assessments will be analyzed to explore trends of use and drive further content development.

Keywords: Art, scientific visualization, information visualization, climate change, art science collaborations, art tech collaborations, Arctic research.

Index Terms: K.3.0 [Computers and Education]: General; J.5

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[Arts and Humanities]: Fine Arts, Literature; H.1.2 [Information Systems]: User/Machine Systems—Human Information Processing; H.5.2 [Information Interfaces and Presentation]: User Interfaces—User Centered Design;

1 INTRODUCTION

Artist Jasper Johns spoke of his work as keys to an unsolvable mystery. With this work we ask whether art can serve as a key into the mysteries and intertwined complexities of science. Our goal is to develop a platform, to which many artists contribute, that becomes a means of entry into the often intimidating complexities of science, specifically climate science. Our challenge is to build a platform that will allow viewers and participants to access the voice, the mode of communication that speaks to them, and motivates them toward a deeper understanding.

Climate change is a daunting topic, its complexity seeming to defy understanding, yet its study has led virtually all scientists in the climate change community to foresee its dire consequences. Their findings have not been accepted as uniformly by Americans, however [5]. The diversity of cultural backgrounds, political leanings, and learning styles lead the population to be diverse in their engagement and conclusions about climate change: some are convinced it is a hoax; some remain disconnected and disengaged with little interest in learning about it; some are convinced of its progress and are motivated to take action. It is the middle, disengaged group who haven't found a way into understanding enough to take a position that this installation aims to reach. *Climate Prisms: The Arctic* aims to make the research manageable and inviting, and it is specifically designed for users to chart their own path of discovery.

We are all prisms. We absorb information and experience. Our life experiences construct a prism through which we interpret our world. Our reactions to, conclusions from, and expressions of that information are the results of the filtration through past experience, through our own individual prism. New information is absorbed and communicated through the prism of our past experiences, with

our own voice. The uniqueness of our past experiences creates unique opportunities to communicate what we absorb. The challenge is to find the voices that resonate, which enable one to hear, absorb and process complexities of our world revealed by science.

Fields such as climate change generate vast amounts of data. To tease understanding from the data we turn to visualization. Visualization is a key link between the soil samples collected in the tundra and the climate models which provide insight into what is to come. This can be seen in 2. Visualization is an abstraction and can be easy to dismiss. *Climate Prisms: The Arctic* presents the pipeline from collecting soil samples in the Arctic to analyzing them in the labs to the statistical analysis of the finding and on to the input into the climate models. By enabling learners to follow the scientists at their sites and in their labs, visually demystify the statistics collected and tie them to the visualization and modeling, we hope to build understanding and acceptance of the results.

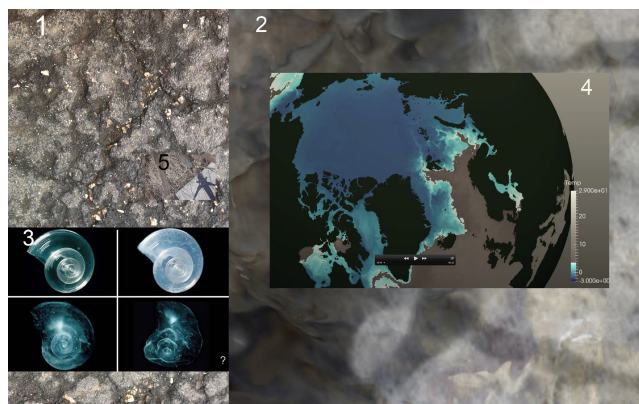


Figure 2: A typical screen display: on the left, artist's photographs (1, 2) are overlaid with shells showing the effect of ocean acidification (3). Also overlaid is a visualization of global ocean surface temperatures focused on the Arctic (4).

An ever-growing body of research in Informal Science Education is showing that the arts contribute greatly to engaging the free-choice learner. This kind of learning goes on outside of the classroom, notably in science centers and museums, where novel, experiential approaches can be piloted. As pointed out by CAISE (Center for Advancement of Informal Science Education), the arts provide ways for both scientists and laypeople to approach understanding scientific content and concepts in new ways, leading to new understandings, making new memories, and establishing new connections and motivations for action [2].

The free-choice learning environment that will be home to the pilot is the Bradbury Science Museum of Los Alamos National Laboratory. Additionally, two traveling systems will expand the reach of the project nationally. The Bradbury currently uses the latest technical approaches to helping learners find their way through science concepts. Many computer and hands-on interactives, iPad apps, videos, and all the traditional fare of photos, graphics, artifacts and text are used. *Climate Prisms: The Arctic* is a strikingly different experiment in engagement. With the entry point through multiple artistic voices, learners hearts and feelings are directly reached, building primarily affective connections and then curiosity, rather than cognitive.

Ensuring that this installation succeeds in reaching the currently disengaged will be assessed through rigorous evaluation. A survey protocol will begin with collecting minimal yet descriptive demographics for each user to assess their current level of interest and view on climate change. Front-end assessment will cover the user interface and content. With content spanning a continuum from the

fine arts to technical scientific jargon, many different languages are part of the participant experience. Initial surveys are planned to assess the content images and language to ensure comprehension by a wide range of demographics. The software code for embedded assessment has been implemented in the pilot project. This will record each individual learners' unique path of discovery. Once data are collected, they will be analyzed to show what trends of use correlate with the descriptive demographics. This will enable a statistical evaluation of the core question: did the project reach the disengaged learner and move that person along the path of understanding and engagement in the issue of climate change? We will also be able to determine which modes of information were most important in engaging learners, providing valuable feedback for development of new content or the distribution of content displayed at each step to a participant.

Climate Prisms: The Arctic aims to makes the research manageable and inviting, and it is specifically designed for users to chart their own path of discovery. It begins with Arctic research and proceeds to why the research impacts global climate models and the role of visualization in constructing models and understanding the predictions.

Climate Prisms: The Arctic presents the science of climate change filtered through many prisms, showing the work of many artists and many scientists. Our intent is to stir curiosity, facilitate contemplation and invite learners to deeper levels of understanding. Our premise is that climate science and current research offer a rich trove of content through which to engage our audience. However science can be intimidating with its jargon and its depth; it can require extended close attention before revealing its wonders. Content delivered via a computer click in a readily accessible fashion, divided into short, easily absorbed bits is today's norm, not usually the way a science story is told.

The Arctic is one of the least understood drivers of climate change. Understanding the changes in this region is critical to building accurate climate models. *Climate Prisms: The Arctic* focuses on how and why the data are collected, how the data are explored through visualization and how the resulting models are verified and validated via visualization. By bringing the experiences of the scientists and research teams into view as they tease understanding from the pond samples, permafrost cores, satellite images, by showing the visual and numerical analyses, by highlighting the means by which the information is compiled and models built, we are shedding light on the means through which climate scientists arrive at their predictions. We draw in our audience through the beauty of science and the environment while we build trust by revealing the processes of science.

The work provides a glimpse into the laboratories, test sites and daily activities, pulling away the veil that surrounds the processes of science. By exposing the research paths, the reasoning and connections for the studies, findings – expected and unexpected -- provide a human connection to the abstraction of the science. Exposing the difficulties and uncertainties inherent in wresting knowledge from ice and soil turns the dialogue to a realm in which we can all relate. We aim to expose the range of experiments, research avenues, interconnectivity, as well as the wonder of discovery and acknowledgment of the known and unknowns that factor into studying climate change.

1.1 The Interface

Viewers and participants engage with *Climate Prisms: The Arctic* via a touch interface driving a large screen. The large wall display presents sets of images, related in content, ranging in type, all linking the collection of data to the visualization. Participants, presented with a set of images, select an image that opens another set of images. The new images are chosen from related and/or tangential categories but varying in types visual, verbal and graphic.

The content is computationally selected based on a system of tags, levels, content relationships and characteristics. Information on the imagery is provided by double-clicking on the imagery as shown in Figure 3.

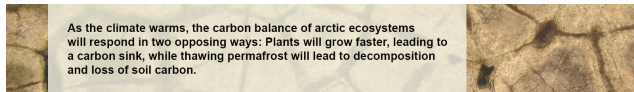


Figure 3: By double-clicking on an image, a learner accesses information about the image.

Viewers can sample a wide variety of content: photographs of the researchers, their field sites, their equipment and materials; scientific visualizations; graphic representations of the data; documentation of the science; poetry based on the scientists' blogs; abstraction and metaphor relating to the relationships within the eco-systems; site maps created by artist / scientist collaboration; visualizations from national laboratory ocean modeling; scientist interviews; journalists' reports; and importantly, the quiet spaces created by abstract imagery. It is these pauses that provide the mental quiet for viewers to internalize the connection between the science and humanity.

Each user experiences is a unique exploration. For example, if one taps a video of drilling tundra cores, the tagging system will pull up a range of content based on that selection. It will produce a randomized range of images, graphs, visualizations, poetry and visual arts all based on the specific content area. No two explorations are the same. The content is deep enough to provide a kaleidoscope of experiences, a diverse means of exploring. *Climate Prisms: The Arctic* is an artistic, ambling trip through the content. It is not linear or program directed. It is designed to open the conversation, enabling learners to formulate their own connections and conclusions.

2 THE CONTENT

The content is organized along three axes. One axis is the range of subject matter. This area is divided into the primary areas of current Arctic research at the national labs: paths of carbon transfer, geomorphology, hydrology, permafrost, and biochemistry.

The second axis is the content continuum between the arts and sciences. It ranges from visual abstractions, poetry, artist-designed maps, to information visualization, scientific visualization and scientist interviews. For example, the far end of the artistic range may hold poems based on scientists' experience working in the Arctic as shown in 4 [9]. The other end of the spectrum might contain a short video of a scientist explaining the reasons for studying the soil composition and why the research is important in predicting climate change. There are interviews with climate modeling scientists explaining the role of visualization in verifying and validating their models as well as visualizations created in collaboration with artists (Figure 5). An aerial view of one of the Barrow, Alaska research sites can be seen in Figure 6. Metaphorical imagery of our relationship to the environment is shown in Figure 7. Typical scientific field notes provides a contrast to the art and exposes the learner to the everyday activities of a scientist "in the wild" (Figure 8 [4]). The participant can also move fully into the domain of validated scientific results such as this plot of the temperature anomalies spanning from 1880 to the present 9. An example of the benefits from artist-scientist collaboration can be seen in Figure 10 [1]. The Arctic tundra consists of polygonal shapes formed by natural forces over the eons. The ability of the scientist to see, explore, and understand these shapes has been improved by a palette of colors developed by a visual artist trained in the use of color.

The third axis is learner-targeted content types and levels. We are creating threads appropriate for young users to seasoned scientists.



Figure 4: A stanza of a poem overlays multiple depictions of the Arctic tundra, ranging from artistic renderings to satellite imagery. Poetry composed by Hannah Wojciehowski, Professor of English at the University of Texas at Austin. Each poem follows the 5-7-5 syllable pattern of traditional Japanese haikus. The poems are based on actual blog postings by climate change scientists stationed in Barrow, Alaska [3]. Each "sci-ku" brings into focus some aspect of the natural landscape, the animal life, the changing of the seasons from winter to spring, and the visible signs of climate change as measured by scientists.

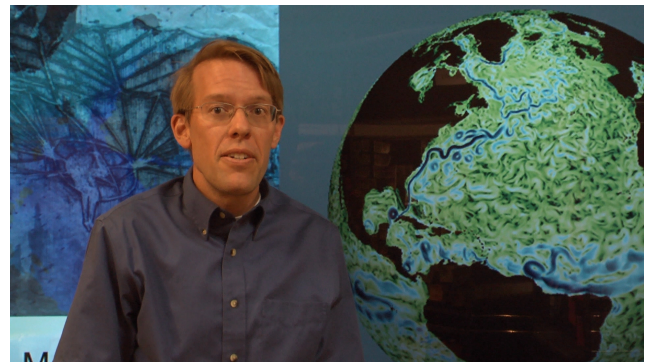


Figure 5: A still shot from a video interview with Dr. Mark Petersen, a climate modeling scientist with the COSIM Team at Los Alamos National Laboratory.



Figure 6: An aerial photograph of one of the research sites in Barrow, Alaska.

On one end of the spectrum we have teens producing interactive animations describing how climate models are built. On the other end will be links to the scientific papers on methods for improving climate models. That said, the content is designed to address learners at their current level of knowledge and entice them to wade in a bit deeper.

We are in discussions with musicians, haptic experts, journalists, rap artists and theater groups for interest in lending their voices to building context between the collection of data and the abstractions of visualization. Our hope is that as the work travels, artists and

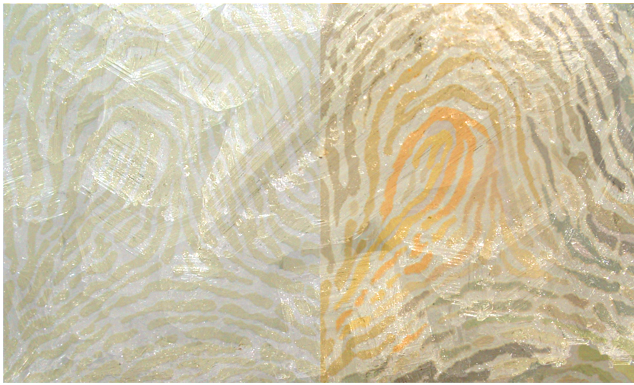


Figure 7: One of the metaphorical images: a combination of a fingerprint etching and a detailed photograph of Arctic ice.

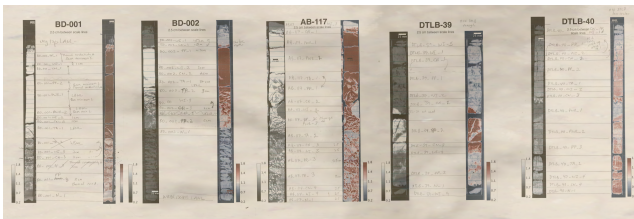


Figure 8: Scientific documentation of tundra core samples.

communicators of all types will step forward to contribute valuable perspectives.

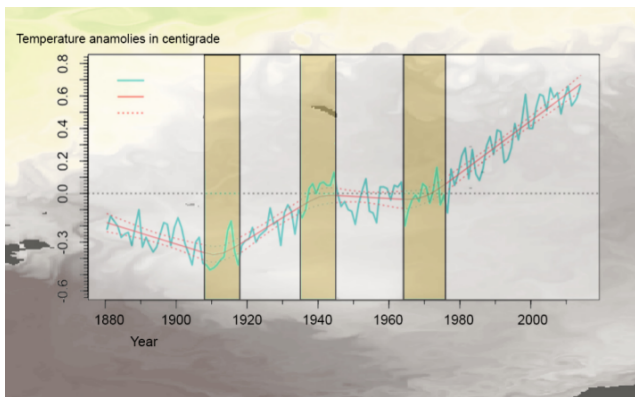


Figure 9: Graph showing temperature anomalies from 1880 to present day.

3 A PILOT STUDY

As presented, the work is a pilot, researching effective means of conveying the connection between the data collected by the scientists and the abstraction of data visualization. We are tracking user paths and audience demographics. The aim is to identify the content that elicits extended exploration as well as areas of interest to those unfamiliar and/or disengaged from the discussion. Results from this embedded assessment will be one of the drivers of future content.

Climate Prisms: The Arctic is a broad collaborative effort. It is not the work of one individual or even one team. It draws on decades of the diversity of scientific research, computer science, visual and verbal communication methodologies, artistic exploration

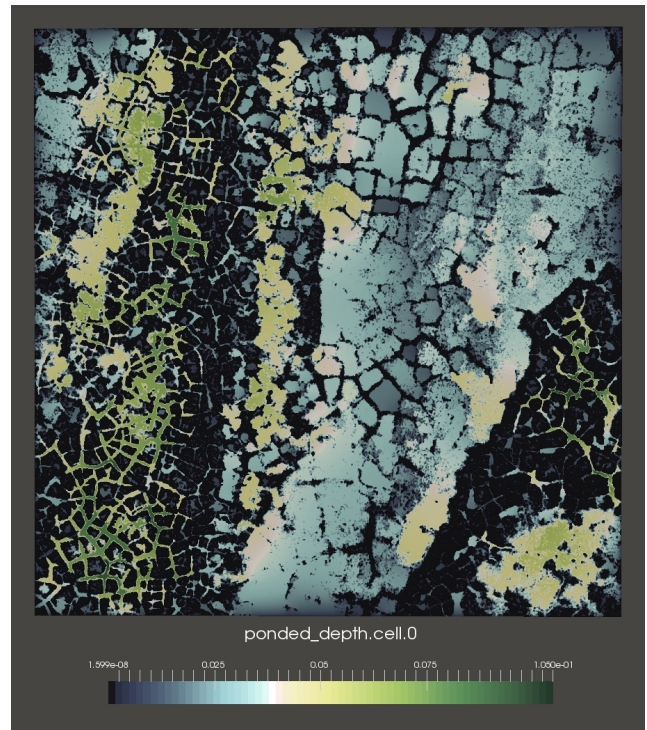


Figure 10: A graphic of a depth within a pond. The characteristic polygonal shapes are highlighted by an artist-developed *colormap*, or color palette, enabling the scientist to see more details within the data.

and cognitive science. It stands on the shoulders of so many while designed to welcome content from those as yet unknown.

Artistic direction is led by Francesca Samsel, Artist-in-Residence at Los Alamos National Laboratory. Cathy Wilson, Los Alamos National Laboratory's Next Generation Environmental Experiments, Senior Scientist, provides the scientific compass. Mark Petersen and the COSIM team at Los Alamos National Laboratory provide the climate modeling knowledge and visualization. Bruce Campbell at the Rhode Island School of Design translates the artistic vision into a computationally-generated experience. Linda Deck, Director of the Bradbury Science Museum maintains our focus on the learner and their experience. The Bradbury has acquired two traveling systems as well as the home system hardware. We propose shipping one of our self-contained traveling systems to VISAP.

3.1 Voices of Art and Science

The ability to reach the general public through innovative means such as museum outreach resonates strongly with both the artistic lead and the involved scientists. Mark Petersen explains why he is so passionate about climate change and communicating it to the public:

Climate change is a special topic in science. There is the duality between getting the research right, and being able to defend it to a great extent. At the same time, we scientists need to simplify the message of the science to communicate it and make it engaging and interesting. As a climate scientist, I think it is part of our responsibility to communicate our work to a broad audience. Working with museum presentations like *Climate Prisms* allows me to contribute my experience as a

scientist, while benefiting from collaborations with specialists in art, communication, and video. [6]

The artist lead, Francesca Samsel, works directly with scientists by using techniques drawn from art to improve visualizations of scientific data. She is equally passionate about communicating scientific concepts to the general public:

My role is an artist who helps scientists extract more information from their visualization. At Los Alamos National Lab, I work with many scientists in a range of disciplines by using my artistic training to help them extract more information from their visualizations. Having a very basic understanding of their research is critical to being able to help them extract the information from the data visualization that they require. In this role, I have to ask a lot of questions, often the "dumb questions". Being able to ask scientists whatever I need to know in order to understand the fundamentals has shown me that science is inherently fascinating and understandable. *Climate Prisms* is about bringing the experience of direct contact with the scientists to a broader audience, not as entertainment but as a means of piecing together how society's level of scientific knowledge impacts us all.

Presenting climate change requires an abstraction of the data — visualization. By linking the daily activities of the scientist to that abstraction, as I do in my work with scientists, we strive to raise the level of understanding, not just of the scientist but of the public as a whole. [8]

4 CONCLUSION

Climate Prisms: The Arctic is an exhibit on climate change but more importantly it is a thinking tool. As participants select and follow paths through the content, the imagery provides a framework for their own internal dialogue. It is the scaffolding upon which learners create their own story line and arrive at their own understanding. *Climate Prisms: The Arctic* is a means for engaging with difficult topics, easing our reticence to contemplate the complex contradictory relationship between our environment and ourselves.

Supporting video can be found at: <https://vimeo.com/131937110>. High resolution photographs and supporting documentation is available at: <https://datascience.lanl.gov/samsel>.

ACKNOWLEDGEMENTS

This work is supported by Los Alamos National Laboratory, the Bradbury Science Museum, and is in collaboration with Linda Deck, Director of the Bradbury Science Museum.

We are so appreciative of our collaboration with Cathy Wilson, Senior Scientist, Earth and Environmental Sciences Division, Los Alamos National Laboratory, who has given us generously of her time over the past year to help us understand the science and bring the project to fruition. Thanks to the entire team from Next-Generation Ecosystem Experiments - Arctic and in particular to Garrett Altmann and Heather Throckmorton for providing content and materials for the project.

We greatly appreciate the collaboration with Mark Petersen, the entire COSIM team, and their generosity in providing the MPAS Ocean model [7]. The MPAS-Ocean model is developed at Los Alamos National Laboratory by the Climate, Ocean, and Sea Ice Model team (COSIM). Core MPAS-Ocean developers include Mark Petersen (CCS-2), Todd Ringler and Douglas Jacobsen (T-3). MPAS-Ocean is a component of the Accelerated Climate Model for Energy, a new climate model by the Department of Energy.

Many thanks to: Craig Tweedie, Systems Ecology Lab, UTEP and his many graduate students for their time explaining the science and contributing materials. Also to the Creative Team Students at the Bradbury Science Museum, including Mireya Rodrigues (Student Lead), David Estrada, Dominic Brooks, Nicole Bariahtaris, and Jack Abram.

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